



Weight Change Following US Military Service

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ORIGINAL ARTICLE

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BACKGROUND: Although overweight and obesity are less prevalent among active-duty military personnel compared with similar persons not serving in the military, no such differences have been observed between veterans and non-veterans.

OBJECTIVES: To assess the magnitude of weight changes before, concurrent with and following discharge from the military, relative to weight during service, and to determine the demographic, service-related and psychological characteristics associated with clinically important weight gain among those who were discharged from military service during follow-up.

METHODS: Eligible Millennium Cohort Study participants ($n = 38\,686$) completed the questionnaires approximately every 3 years (2001, 2004 and 2007) that were used to estimate annual weight changes, as well as the percentage experiencing clinically important weight gain, defined as $\geq 10\%$. Analyses were stratified by sex.

RESULTS: Weight gain was greatest around the time of discharge from service and in the 3 years before discharge (1.0–1.3 kg per year), while it was nearly half as much during service (0.6–0.7 kg per year) and ≥ 3 years after service ended (0.7 kg per year). Consequently, 6-year weight gain was over 2 kg greater in those who were discharged compared with those who remained in the military during follow-up (5.7 vs 3.5 kg in men; 6.3 vs 4.0 kg in women). In those who were discharged, younger age, less education, being overweight at baseline, being in the active-duty component (vs Reserve/National Guard) and having experienced deployment with combat exposures (vs non-deployment) were associated with increased risks of clinically important weight gain.

CONCLUSIONS: This study provides the first prospectively collected evidence for an increased rate of weight gain around the time of military discharge that may explain previously reported higher rates of obesity in veterans, and identifies characteristics of higher-risk groups. Discharge from military service presents a window of risk and opportunity to prevent unhealthy weight gain in military personnel and veterans.

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INTRODUCTION

To ensure military readiness, weight for height and body composition standards must be met for accession into the military and on a semi-annual basis for retention and promotion.¹ Not surprisingly, the prevalence of obesity in military populations has been found to be lower than in civilian populations.^{2,3} Despite selection for and an emphasis on fitness and maintaining a healthy weight, older veterans appear to have a similar, if not greater prevalence of overweight and/or obesity than non-veterans of similar age and sex.^{4–7} This paradox suggests that the rate of weight gain following termination of military service may be greater among former military personnel than among those who never served in the military. Results from a recently published study provide support for this hypothesis; findings suggested that there may have been a 'burst' of weight gain after military discharge.⁸ However, a limitation of this study was that weight change was assessed using current and recalled weight and no information was available on how long individuals had served in the military and when they were discharged.

Because of the adverse health outcomes associated with overweight and obesity, studies using prospectively collected data, from individuals serving in the current conflicts, are needed

to better understand this critical transitional period and to identify groups that may be at high risk of excess weight gain. The Millennium Cohort Study is a population-based study of military personnel, and includes both active-duty and Reserve/National Guard personnel, as well as women and men, and offers an opportunity to assess weight changes during the transition from military to civilian life using longitudinally collected data. The first aim of this study was to assess whether weight gain rates differed between those who were discharged during follow-up compared with those who remained in the military, and if so, at what point in time, relative to discharge, the increased weight gain rate occurred. A second aim was to evaluate, among those who were discharged during follow-up, the association between demographic, service-related and psychological characteristics and clinically important weight gain. We hypothesized that subgroups that might be particularly vulnerable to weight gain would include those with mental or physical health conditions, such as posttraumatic stress disorder (PTSD), as well as those who were deployed in support of the wars in Iraq and Afghanistan. As over 2.2 million troops have deployed (<http://www.npr.org/2011/07/03/137536111/by-the-numbers-todays-military>), it is of particular interest how deployment, with or without combat exposure, may affect weight trajectories.

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MATERIALS AND METHODS

Study population and data sources

The sampling frame and participant recruitment procedures for the Millennium Cohort Study have been described in detail elsewhere.⁹ Briefly, a population based, weighted sample was randomly selected from all US military personnel actively serving as of October 2000. Beginning in 2001, a modified Dillman approach was used to maximize response while minimizing costs to recruit and retain the cohort.¹⁰ Cohort members were re contacted via e mail and postal service to complete a follow up survey approximately every 3 years (that is in 2004 and 2007). All enrolled subjects provided informed consent. This study was approved by the Institutional Review Board at the Naval Health Research Center, San Diego (protocol number NHRC.2000.0007).

Demographic and military data were obtained from the electronic personnel files of the Defense Manpower Data Center and included sex; birth date; race/ethnicity; highest year of education; marital status; branch of service; service component; military pay grade; military occupation; deployment experience in support of the wars in Iraq and Afghanistan between 2001 and 2004; and duration of service, including military discharge status.

Discharge from the military

Individuals were classified as discharged if they had an interservice separation code indicating discharge from the military and they remained out of the service (based on linkage to monthly pay files) for at least 3 consecutive months before and including their survey completion date. For some analyses, we conducted analyses separately among those who were discharged from the military between 2001 and the 2004 and those who were discharged from the military between 2004 and 2007. The number of years since discharge was calculated by subtracting each individual's date of discharge from their 2007 survey completion date.

Weight changes

Weight changes, derived from self reported weights, were examined as both continuous and categorical measures. Average annual weight changes were calculated as the difference in self reported current weight at each survey, divided by the time in years between surveys, since the time interval between survey completions varied between participants. The average time interval was 2.7 years from baseline to the first follow up, and 2.9 years from the first follow up until the second.

Other covariate data

Self reported data on height, diagnosed medical conditions, symptoms (including PTSD and depression), use of tobacco, as well as military specific and occupational exposures were obtained from the Millennium Cohort Study questionnaire.⁹ Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Individuals were classified according to their smoking status in 2004 as either a persistent never smoker (never smoker in 2001 and 2004), persistent former smoker (former smoker in 2001 and 2004), recent quitter (current or never smoker in 2001 and former smoker in 2004) or current smoker. PTSD was assessed through the PTSD checklist, Civilian Version (PCL C), a 17 item screening tool that asks respondents to rate the severity of each symptom during the past 30 days on a 5 point Likert scale ranging from 1 (not at all) to 5 (extremely).¹¹ Individuals were classified as screening positive for PTSD if they self reported a moderate or higher level of at least one intrusion symptom, three avoidance symptoms and two hyperarousal symptoms (criteria established by the *DSM IV* (*Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition)).¹² The Patient Health Questionnaire 9 item screening tool was used to assess depression, which corresponds to the diagnosis for depression from the *DSM IV*.¹³ A 4 point Likert scale was used to rate the severity of depression symptoms from 1 (not at all) to 4 (nearly every day) during the 2 weeks before questionnaire completion. Individuals were classified as screening positive for depression if they endorsed having a depressed mood or anhedonia and responded 'more than half the days' or 'nearly every day' to at least five of the nine items,

where thoughts of being better off dead or hurting oneself were counted if present at all.¹⁴

Statistical analyses

The difference between groups in mean weight change was calculated by subtracting the mean weight change of the reference group (continuing service members) from the mean weight change of those who were discharged from the military during follow up. Statistical significance was assessed by χ^2 tests across categories and defined as $P < 0.05$. To investigate the extent to which weight change differences between the groups might be explained by demographic, military and behavioral risk factors, we used generalized linear models (Proc GLM in SAS), adjusting for time between surveys, age, sex, BMI, education, marital status, race/ethnicity, service component, branch of service, smoking status, PTSD and depression symptoms (categories as presented in Table 1). P values for the differences in the least squares mean values compared with the reference group were adjusted for multiple comparisons using the Scheffe method. Although physical activity was measured in 2004, it was not considered a potential confounder, since it may be in the causal pathway between discharge status and weight change. The Millennium Cohort study did not collect detailed information on diet.

To evaluate how 6 year weight changes varied across characteristics (for example, in those with vs without PTSD), univariate linear regression models were created to determine whether weight changes differed statistically from each other.

Finally, logistic regression models were employed to estimate odds ratios and 95% confidence intervals of clinically important 6 year weight gain in those who were discharged during follow up. Clinically important weight gain was defined as $\geq 10\%$ body weight gain (http://www.nhlbi.nih.gov/guidelines/obesity/prctgd_c.pdf). To identify independent associations between demographic, military and health characteristics, models were mutually adjusted for all factors presented. Continuing service members were not included in these analyses.

RESULTS

Of the 77 047 eligible individuals who completed baseline surveys between July 2001 and June 2003, 71% ($n = 55 021$) completed the first follow-up survey between June 2004 and February 2006, and 54 790 completed the second follow-up survey between May 2007 and December 2009. The 46 438 individuals who completed all three surveys were considered for inclusion in this study. Individuals with the following characteristics were subsequently excluded: those who had been discharged from the military by the time they completed the baseline survey ($n = 2434$); who were missing for weight ($n = 3890$) or reported a biologically implausible value for height (< 4 feet or > 7 for women or > 8 feet for men), weight (< 31.8 kg for women or < 40.9 kg for men or > 227.2 kg for men or women) or calculated BMI (< 15 and > 80 kg m⁻²) ($n = 52$); and who were missing covariate data ($n = 1509$), leaving a total of 38 553 individuals for analyses.

Approximately 10% ($n = 4000$) of study participants were discharged from the military between 2001 and 2004, 10% ($n = 3845$) were discharged between 2004 and 2007 and the remainder ($n = 30 708$) remained in the military during follow-up (Table 1). Compared with continuing service members, women who were discharged from the military during follow-up were more likely to be born after 1973 while men who were discharged from the military during follow-up were more likely to be born between 1960 and 1966 (that is, ≥ 40 years of age by 2007, $P < 0.0001$). Additionally, those who were discharged from the military during follow-up were more likely to have had only a high school diploma, be married (men only), be of other race/ethnicity, have a BMI ≥ 25 kg m⁻², be a current smoker, have a positive screen for PTSD or depression and be active-duty (vs Reserve/National Guard), Navy/Coast Guard or Marine Corps personnel (all $P < 0.005$). Compared with those who were discharged

Table 1. Characteristics^a of Millennium Cohort Study participants by military status (n = 38 686)

Characteristics ^a	Men			Women		
	D1 (%)	D2 (%)	CSM (%)	D1 (%)	D2 (%)	CSM (%)
N	2912	2914	23 008	1088	931	7700
<i>Birth year</i>						
1979 or later	4.3	4.7	3.8	11.1	10.7	8.3
1973–1978	13.7	10.1	15.7	25.1	24.5	18.2
1967–1972	7.8	13.1	26.3	13.0	15.3	23.1
1960–1966	39.3	49.0	27.8	26.6	33.2	26.5
1959 or earlier	34.9	23.2	26.4	24.3	16.3	23.9
<i>Education</i>						
Less than high school diploma	4.1	3.8	4.8	5.1	4.8	6.8
High school graduate	45.2	40.7	35.4	42.9	42.4	32.2
Some college	24.9	27.8	26.4	22.5	25.9	26.0
Bachelor's degree	11.9	13.1	22.5	16.4	13.9	22.2
Postgraduate degree	13.9	14.6	11.0	13.1	13.0	12.9
<i>Marital status</i>						
Not married	23.6	22.0	26.9	47.2	50.8	49.3
Married	76.4	78.0	73.1	52.8	49.2	50.7
<i>Race/ethnicity</i>						
Non Hispanic white	72.9	69.2	74.8	64.7	59.8	65.4
Non Hispanic black	9.8	10.4	8.5	17.3	21.1	18.9
Other	17.3	20.4	16.8	18.0	19.1	15.8
<i>Body mass index (kg m⁻²)</i>						
<18.5	0.3	0.2	0.3	2.3	1.7	1.8
18.5–24.9	22.5	23.5	27.5	55.0	54.9	62.6
25.0–29.9	61.3	61.9	60.5	34.3	37.7	30.8
≥30	15.9	14.3	11.8	8.5	5.7	4.9
<i>Physical activity^b</i>						
Insufficiently active	19.1	16.7	16.5	24.9	20.2	19.7
Met physical activity guidelines	56.3	67.6	68.3	53.2	63.3	64.5
Missing	24.6	15.7	15.2	21.9	16.5	15.8
<i>Smoking status in 2004</i>						
Persistent never smoker	50.2	53.5	58.0	56.2	59.5	62.6
Persistent former smoker	27.3	25.8	22.1	22.4	20.0	20.1
Recent quitter	6.7	5.4	6.1	6.2	5.3	5.1
Current smoker	15.8	15.3	13.8	15.3	15.3	12.1
<i>Posttraumatic stress disorder symptoms</i>						
No	94.9	95.9	97.3	92.7	94.3	96.4
Yes	5.1	4.1	2.7	7.4	5.7	3.6
<i>Depression symptoms</i>						
No	96.6	97.4	98.3	93.9	95.4	96.9
Yes	3.4	2.6	1.7	6.1	4.6	3.1
<i>Deployment experience between the 2001 and 2004 surveys</i>						
Not deployed	86.4	64.7	64.5	91.8	76.1	79.2
Deployed without combat exposures	6.9	15.5	17.5	4.9	11.9	11.5
Deployed with combat exposures	6.7	19.8	17.9	3.3	12.0	9.3
<i>Service component</i>						
Active duty	80.8	87.6	48.2	75.3	78.1	40.9
Reserve/National Guard	19.2	12.4	51.8	24.7	21.9	59.1
<i>Branch of service</i>						
Army	44.1	44.5	47.5	50.1	52.4	49.4
Navy/Coast Guard	26.3	23.1	17.3	24.5	21.6	17.4
Marine Corps	5.8	5.3	4.1	3.7	2.4	1.6
Air Force	23.7	27.1	31.2	21.8	23.6	31.6
<i>Years of military service</i>						
<10	20.7	12.2	17.0	44.0	30.0	27.3
10–13	5.6	6.5	14.0	7.4	12.8	13.9
14–20	27.1	21.5	34.1	21.7	23.3	32.9
21–25	29.7	42.4	18.2	21.3	25.5	16.7
≥26	16.9	17.5	16.6	5.6	8.5	9.2

Table 1 (Continued)

Characteristics ^a	Men			Women		
	D1 (%)	D2 (%)	CSM (%)	D1 (%)	D2 (%)	CSM (%)
N	2912	2914	23 008	1088	931	7700
Years since discharge at time of 2007 survey						
<3		94.5		5.4	91.5	
3 <4	33.0	5.4		32.1	8.2	
4 <5	36.9	0.1		34.6	0.3	
≥5	22.8	0.0		27.9	0.0	

Abbreviations: CSM, continuing service members, which include those who remained in the military until the end of follow up; D1, individuals who were discharged from the military between 2001 and 2004; D2, individuals who were discharged from the military between 2004 and 2007. ^aAll characteristics reflect those measured at baseline, unless otherwise stated. $\chi^2 P < 0.0001$ for all characteristics in men, and in women with the following exceptions: marital status ($P = 0.26$), race/ethnicity ($P = 0.004$) and smoking status ($P = 0.0005$). ^bMeeting guidelines was defined as ≥ 150 min per week of moderate activity or ≥ 75 min of vigorous activity, or an equivalent combination of the two, where each minute of vigorous activity is doubled. Insufficiently active is defined as < 150 min per week of activity.

Table 2. Average annual weight changes and differences in annual and 6 year changes in weight (kg) by military discharge status, Millennium Cohort Study, 2001–2007

	Discharged from the military between 2001 and 2004	Discharged from the military between 2004 and 2007	Remained in the military during follow up
Average annual weight change (kg per year) ^a		Mean (95% CI)	
2001–2004			
Overall	+1.3 (+1.3, +1.4)	+1.0 (+0.9, +1.1)	+0.7 (+0.7, +0.7)
Men	+1.3 (+1.2, +1.3)	+0.9 (+0.8, +0.9)	+0.7 (+0.6, +0.7)
Women	+1.5 (+1.3, +1.6)	+1.3 (+1.1, +1.5)	+0.9 (+0.8, +0.9)
2004–2007			
Overall	+0.7 (+0.6, +0.7)	+1.2 (+0.9, +1.1)	+0.6 (+0.6, +0.6)
Men	+0.7 (+0.6, +0.8)	+1.2 (+1.1, +1.3)	+0.6 (+0.6, +0.6)
Women	+0.6 (+0.4, +0.7)	+1.2 (+1.0, +1.3)	+0.6 (+0.5, +0.6)
Difference in average annual weight change (95% CI) ^b			
2001–2004			
Overall	+0.6 (+0.5, +0.7)	+0.3 (+0.2, +0.3)	Reference
Men	+0.6 (+0.5, +0.7)	+0.2 (+0.1, +0.3)	Reference
Women	+0.6 (+0.4, +0.8)	+0.4 (+0.2, +0.6)	Reference
2004–2007			
Overall	+0.3 (0.1, +0.1)	+0.5 (+0.5, +0.6)	Reference
Men	+0.1 (0.0, +0.2)	+0.5 (+0.4, +0.6)	Reference
Women	0.1 (0.2, +0.1)	+0.6 (+0.4, +0.7)	Reference
Difference in 6 year weight change from 2001 to 2007 (95% CI) ^b			
Overall	+1.7 (+1.3, +2.0)	+2.1 (+1.8, +2.5)	Reference
Men	+1.6 (+1.2, +2.0)	+2.1 (+1.8, +2.5)	Reference
Women	+1.9 (+1.2, +2.6)	+2.2 (+1.5, +2.9)	Reference

Abbreviation: CI, confidence interval. ^aNote that 2001–2004 represents the time period concurrent with discharge for those who were discharged from the military between 2001 and 2004 and 2004–2007 represents the time period following discharge for this group and concurrent with discharge for those who were discharged from the military between 2004 and 2007. ^bAdjusted for time between surveys, age, sex (overall estimates only), body mass index, education, marital status, race/ethnicity, service component, branch of service, smoking status, posttraumatic stress disorder symptoms and depression symptoms.

between 2004 and 2007, those who were discharged between 2001 and 2004 were more likely to be born in 1959 or earlier (that is, ≥ 40 years of age in 2001), to be insufficiently active or have missing data on physical activity, to have not been deployed between 2001 and 2004, and to have < 10 years of service (all $P < 0.0001$).

Mean annual weight gain rates were nearly two times greater during the period concurrent with discharge (1.2–1.3 kg per year) and before discharge (1.0 kg per year) than during service (0.6–0.7 kg per year among continuing service members) or in the years following discharge (0.7 kg per year; Table 2). After multivariable adjustment, mean annual weight changes were about 0.3 kg per

year greater 1 to 6 years before discharge (that is, between 2001 and 2004 in those who were discharged between 2004 and 2007) and ~ 0.5 – 0.6 kg per year greater concurrent with discharge, relative to weight gain rates among those who remained in the military during follow-up.

Over ~ 6 years, men and women who left the military gained an average of 5.7 and 6.3 kg, respectively, compared with 3.5 and 4.0 kg, respectively, in continuing service members (Tables 3 and 4). Patterns were generally similar in men and women, although estimates were less precise in women because of smaller numbers. Weight gain was monotonically and inversely associated

with age and was greater among those with only a high school education compared with those who had a postgraduate degree. Relative to normal weight men, weight gain was 1.2 and 2.5 kg greater in overweight and obese men who were discharged during follow-up, respectively, whereas it was 0.5 and 0.4 kg less in overweight and obese men who remained in the military (all $P < 0.05$). Findings were somewhat less consistent in women, though pointed towards similar trends. Specifically, weight gain was statistically significantly greater in overweight, but not obese women who were discharged (2.9 and 0.6 kg, respectively). Female continuing service members who were obese gained significantly less weight (1.4 kg) than continuing service members who were normal weight. In both those who were discharged and continuing service members, those with PTSD and/or depression gained more weight than those without (though the difference for depression in women who were discharged did not achieve statistical significance). Finally, weight gain was statistically significantly lower in those who had served ≥ 14 years (vs those who had served < 10) for men who had been discharged and both male and female continuing service members.

Table 5 presents odds ratios for the associations between various characteristics and clinically important weight gain in men and women who were discharged, with each characteristic mutually adjusted for all other characteristics. The prevalence of clinically important weight gain was over 11 percentage points greater in women than in men (40.1% vs 28.7%, adjusted odds ratio = 1.8, 95% confidence interval: 1.59, 2.03). In the sex-stratified models, the following characteristics had odds ratios of clinically important weight gain > 1 : birth years between 1960 and 1972 (vs < 1959 in men and women, and additionally birth years in 1973 and later in men only), some college or less (vs having a postgraduate degree), overweight (men and women), obesity (men only) and deployment with combat exposure. Conversely, blacks and those with 'other' race/ethnicity (vs non-Hispanic whites, men only), those in the Reserve/National Guard (vs active duty) and Navy/Coast Guard members (vs the Army) had decreased odds of clinically important weight gain.

DISCUSSION

Weight gain rates in those who were discharged from the military increased before and around the time of discharge from military service and resulted in ~ 2.2 kg of additional weight gain over the course of 6 years, and a near tripling of obesity, from 12 to 31%. Differences observed between those who were and were not discharged from the military could not be explained by confounding by demographic, military or health-related factors. However, estimates did not change appreciably after statistical adjustment. Although we lacked data to determine why individuals who were discharged from the military gained more weight around the time of their discharge than those who remained in the military, it is plausible that excess weight gain was due to lower levels of energy expenditure (that is, physical activity), without a compensatory decrease in energy consumption.

When doing their usual jobs—even when deployed—military members, for the most part, have the freedom to choose what and how much they eat and exercise. The main constraint to this freedom is that the military personnel must maintain a standard for fitness and weight/body composition that is checked at 6–12 months intervals. Individuals who fail to achieve this standard may face adverse career consequences including restriction from promotion, obstruction from attending professional military schools and discharge from the military service in extreme cases. One reason that the weight/body composition standards were established and are enforced is to present a 'military appearance'.¹⁵ Appearance is considered to be important because it

affects how the general public views the military and is believed to provide an *esprit de corps*. One might hypothesize that after years of service, military members would internalize the military standard of appearance, and that this mind-set would be sufficiently ingrained to motivate healthy weight maintenance even after enforcement of standards ceased. Data from the current study do not support that hypothesis and instead suggest that enforcement of the physical fitness and body composition standards via negative consequences (vs motivation due to intrinsic factors) may have been a primary motivator for service members to prevent unhealthy weight gain. This hypothesis is supported by the observation that mean weight gain was greater in the 3–6 years before discharge, as there may have been a reduced threat of adverse career consequences for not meeting the body composition standards. In addition, while continuing service members who were overweight had less weight gain than their normal weight counterparts (presumably out of the necessity to show progress towards the body composition standards), the opposite was true in those who were discharged from the military during follow-up (more weight gain).

Women had a much greater prevalence of clinically important weight gain than men, and the differences were not explained by demographic, military or health factors. These results emphasize the importance of not only looking at means, but also associations based on relative weight changes using clinically relevant thresholds, as the mean weight changes in men and women were similar, but women who were discharged from the military during follow-up were significantly more likely to gain a relatively large amount of weight than men. Such differences between men and women has been observed previously, but the reasons are poorly understood.^{16,17} Understanding the mediators of these associations, for example, changes in physical activity and diet, could help to identify how interventions targeted at weight maintenance or loss might need to be tailored for men and women.

Risk of clinically important weight gain was greater in those who deployed with combat exposures. A qualitative study of postservice eating behaviors in 64 American veterans (51% from Vietnam, 12.5% from Korean War, 9.4% from WWII, and 1.6% from the current conflicts) lend some insight into potential mechanisms.¹⁸ Study participants noted that they did not decrease or change their eating behaviors after completing their military service even though they substantially decreased their physical activity. Also, the need to eat a large quantity of food quickly due to time constraints was a behavior many cited as the reason for weight gain after service. Finally, food was used as a coping mechanism to deal with stress and anxiety. These sorts of behaviors may partly explain the associations observed in the current study, but more information is needed to understand the mechanisms in this population.

Reserve/National Guard members had a reduced risk of clinically important weight gain following discharge relative to active-duty personnel. Although it is plausible that Reserve/National Guard members might be heavier to start with and results were due to regression to the mean, this was not the case as the mean BMI of Reserve/National Guard members who were discharged was slightly lower than active-duty component members who were discharged (26.1 vs 26.5 kg m⁻²). Reserve/National Guard members often have civilian jobs and live in non-military communities except for during trainings (~ 1 weekend per month plus 2 weeks per year) and times of deployment. As such, they must take daily responsibility for their eating and exercise in order to meet their service branch's standards. Straddling the military and civilian worlds, these individuals may have gained more self-monitoring and/or self-control skills that translated to their postmilitary experience. Understanding the successful strategies to prevent weight gain employed by Reserve/National Guard members would be a fruitful area of future research.

Table 3. 6 year changes in weight (kg) between 2001 and 2007 in male Millennium Cohort Study members who remained and did not remain in the military during follow up, stratified by various characteristics^a

Characteristic	Discharged from the military during follow up N = 5826		Remained in the military during follow up N = 23 008	
	Mean weight Δ (kg)	Mean weight Δ difference (kg) compared with the reference category (95% CI)	Mean weight Δ (kg)	Mean weight Δ difference (kg) compared with the reference category (95% CI)
Overall	+5.7		+3.5	
<i>Birth year</i>				
1979 or later	+8.8	+4.8 (+3.2, +6.5)	+6.8	+4.0 (+3.3, +4.7)
1973–1978	+7.5	+3.5 (+2.4, +4.6)	+4.6	+1.8 (+1.4, +2.2)
1967–1972	+6.5	+2.5 (+1.4, +3.7)	+3.4	+0.6 (+0.3, +0.9)
1960–1966	+5.7	+1.7 (+0.9, +2.5)	+3.4	+0.5 (+0.2, +0.9)
1959 or earlier	+4.0	Ref	2.8	Ref
<i>Education</i>				
Less than high school diploma	+5.3	+1.5 (0.3, +3.3)	+4.1	+1.9 (+1.2, +2.5)
High school graduate	+6.6	+2.8 (+1.8, +3.8)	+4.3	+2.0 (+1.6, +2.4)
Some college	+5.6	+1.9 (+1.8, +2.9)	+3.6	+1.4 (+0.9, +1.8)
Bachelor's degree	+4.7	+0.9 (0.3, +2.2)	+2.8	+0.5 (+0.02, +0.9)
Postgraduate degree	+3.8	Ref	+2.3	Ref
<i>Race/ethnicity</i>				
Non Hispanic white	+5.8	Ref	+3.6	Ref
Non Hispanic black	+5.7	0.3 (1.1, +0.6)	+4.0	+0.5 (+0.1, +0.8)
Other	+5.1	0.7 (1.4, 0.1)	+3.3	0.3 (0.5, 0.01)
<i>Marital status</i>				
Not married	+6.5	+1.2 (+0.7, +1.7)	+4.3	+1.1 (+0.9, +1.3)
Married	+5.4	Ref	+3.3	Ref
<i>Body mass index (kg m⁻²)</i>				
<18.5	+6.9	+2.4 (3.1, +7.9)	+15.0	+11.2 (+9.1, +13.3)
18.5–24.9	+4.5	Ref	+3.8	Ref
25.0–29.9	+5.7	+1.2 (+0.5, +1.9)	+3.4	0.5 (0.7, 0.2)
≥30	+7.0	+2.5 (+1.5, +3.5)	+3.4	0.4 (0.8, 0.02)
<i>Smoking status in 2004</i>				
Persistent never smoker	+5.5	Ref	+3.4	Ref
Persistent former smoker	+5.7	+0.2 (0.5, +0.9)	+3.5	+0.1 (0.1, +0.4)
Recent quitter	+6.9	+1.4 (+0.1, +2.6)	+4.4	+1.0 (+0.6, +1.5)
Current smoker	+5.7	+0.2 (0.7, +1.0)	+3.9	+0.5 (+0.2, +0.8)
<i>Posttraumatic stress disorder symptoms</i>				
No	+5.5	Ref	+3.5	Ref
Yes	+8.2	+2.7 (+1.7, +3.6)	+5.1	+1.6 (+1.1, +2.1)
<i>Depression symptoms</i>				
No	+5.6	Ref	+3.5	Ref
Yes	+8.9	+3.4 (+2.2, +4.6)	+5.5	+2.0 (+1.3, +2.6)
<i>Deployment experience between the 2001 and 2004 surveys</i>				
Not deployed	+5.5	Ref	+3.4	Ref
Deployed without combat exposures	+5.7	+0.2 (0.6, +1.1)	+3.6	+0.2 (0.04, +0.5)
Deployed with combat exposures	+6.5	+1.1 (+0.3, +1.8)	+4.1	+0.7 (+0.4, +1.0)
<i>Service component</i>				
Active duty	+5.8	Ref	+3.6	Ref
Reserve/National Guard	+4.8	1.0 (1.6, 0.4)	+3.5	0.1 (0.3, +0.05)
<i>Branch of service</i>				
Army	+6.1	Ref	+3.9	Ref
Navy/Coast Guard	+5.1	0.9 (1.7, 0.2)	+3.1	0.8 (1.1, 0.5)
Marine Corps	+7.1	+1.0 (0.3, +2.3)	+3.6	0.3 (0.9, +0.3)
Air Force	+5.2	0.9 (1.6, 0.1)	+3.3	0.6 (0.8, 0.3)
<i>Years of military service</i>				
<10	+7.4	Ref	+4.9	Ref
10–13	+7.0	0.4 (2.0, +1.1)	+3.4	1.5 (2.0, 1.1)
14–20	+5.6	1.8 (2.9, 0.8)	+3.3	1.6 (1.9, 1.2)
21–25	+5.5	2.0 (2.9, 1.0)	+3.5	1.4 (1.8, 1.0)
≥26	+3.9	3.5 (4.6, 2.4)	+2.8	2.1 (2.5, 1.7)

^aAll characteristics reflect those measured at baseline, unless otherwise stated. Bold font indicates that $P < 0.05$ for weight change difference estimates relative to the reference category.

Table 4. 6 year changes in weight (kg) between 2001 and 2007 in female Millennium Cohort Study members who remained and did not remain in the military during follow up, stratified by various characteristics^a

Characteristic	Discharged from the military during follow up, N = 2019		Remained in the military during follow up, N = 7700	
	Mean weight Δ (kg)	Mean weight Δ difference (kg) compared with the reference category (95% CI)	Mean weight Δ (kg)	Mean weight Δ difference (kg) compared with the reference category (95% CI)
Overall	+6.3		+4.0	
<i>Birth year</i>				
1979 or later	+7.7	+3.5 (+1.3, +5.8)	+5.5	+2.1 (+1.2, +3.1)
1973-1978	+7.0	+2.8 (+1.0, +4.6)	+4.5	+1.1 (+0.4, +1.8)
1967-1972	+6.5	+2.2 (+0.1, +4.3)	+4.0	+0.6 (0.04, +1.3)
1960-1966	+6.4	+2.2 (+0.5, +3.9)	+3.8	+0.4 (0.3, +1.1)
1959 or earlier	+4.2	Ref	+3.4	Ref
<i>Education</i>				
Less than high school diploma	+6.5	+2.6 (0.6, +5.7)	+4.5	+1.6 (+0.5, +2.7)
High school graduate	+7.4	+3.5 (+1.6, +5.4)	+4.6	+1.7 (+1.0, +2.5)
Some college	+6.6	+2.7 (+0.6, +4.8)	+4.3	+1.3 (+0.5, +2.1)
Bachelor's degree	+4.7	+0.8 (1.5, +3.1)	+3.3	+0.4 (0.4, +1.2)
Postgraduate degree	+3.9	Ref	+2.9	Ref
<i>Race/ethnicity</i>				
Non Hispanic white	+6.4	Ref	+4.0	Ref
Non Hispanic black	+6.9	+0.5 (0.7, +1.8)	+4.7	+0.7 (+0.2, +1.2)
Other	+5.4	1.0 (2.2, +0.3)	+3.4	0.6 (1.1, 0.1)
<i>Marital status</i>				
Not married	+7.1	+1.5 (+0.8, +2.3)	+4.5	+0.9 (+0.6, +1.2)
Married	+5.5	Ref	+3.6	Ref
<i>Body mass index (kg m⁻²)</i>				
<18.5	+7.0	+1.9 (2.0, +5.8)	+4.8	+0.8 (0.7, +2.5)
18.5-24.9	+5.2	Ref	+3.9	Ref
25.0-29.9	+8.0	+2.9 (+1.7, +4.1)	+4.4	+0.6 (+0.1, +1.0)
≥30	+5.8	+0.6 (1.5, +2.8)	+2.5	1.4 (2.4, 0.4)
<i>Smoking status in 2004</i>				
Persistent never smoker	+6.3	Ref	+4.0	Ref
Persistent former smoker	+5.9	0.4 (1.8, +1.0)	+3.7	0.2 (0.8, +0.3)
Recent quitter	+7.3	+1.0 (1.4, +3.4)	+4.7	+0.7 (0.3, +1.7)
Current smoker	+6.4	+0.2 (1.4, +1.8)	+4.4	+0.5 (0.2, +1.1)
<i>Posttraumatic stress disorder symptoms</i>				
No	+6.2	Ref	+3.9	Ref
Yes	+7.9	+1.8 (+0.2, +3.3)	+6.3	+2.4 (+1.6, +3.2)
<i>Depression symptoms</i>				
No	+6.2	Ref	+4.0	Ref
Yes	+7.4	+1.2 (0.5, +2.9)	+5.4	+1.5 (+0.6, +2.3)
<i>Deployment experience between the 2001 and 2004 surveys</i>				
Not deployed	+6.0	Ref	+3.9	Ref
Deployed without combat exposures	+7.7	+1.8 (0.01, +3.5)	+4.4	+0.5 (0.1, +1.1)
Deployed with combat exposures	+8.0	+2.0 (+0.2, +3.9)	+4.3	+0.4 (0.3, +1.0)
<i>Service component</i>				
Active duty	+6.5	Ref	+4.0	Ref
Reserve/National Guard	+5.5	1.1 (2.0, 0.2)	+4.0	+0.02 (0.3, +0.3)
<i>Branch of service</i>				
Army	+6.2	Ref	+4.1	Ref
Navy/Coast Guard	+5.8	0.4 (1.8, +1.0)	+3.6	0.5 (1.1, +0.1)
Marine Corps	+7.4	+1.2 (2.0, +4.5)	+4.2	+0.1 (1.6, +1.8)
Air Force	+6.7	+0.5 (0.9, +1.9)	+4.2	+0.1 (0.4, +0.6)
<i>Years of military service</i>				
<10	+6.9	Ref	+4.6	Ref
10-13	+7.0	+0.1 (2.0, +2.3)	+3.8	0.8 (1.6, 0.1)
14-20	+6.0	0.9 (2.6, +0.7)	+3.9	0.7 (1.3, 0.1)
21-25	+5.6	1.3 (2.9, +0.3)	+3.7	0.9 (1.7, 0.2)
≥26	+5.0	1.9 (4.4, +0.6)	+3.4	1.2 (2.1, 0.3)

^aAll characteristics reflect those measured at baseline, unless otherwise stated. Bold font indicates that $P < 0.05$ for weight change difference estimates relative to the reference category.

Table 5. Multivariable adjusted associations of demographic, military and risk factor characteristics and clinically important weight gain^a over 6 years in men and women who were discharged from the military during follow up, Millennium Cohort Study, 2001–2007

Characteristic	Men			Women		
	Clinically important weight gain (%)	OR ^b	95% CI	Clinically important weight gain (%)	OR ^b	95% CI
Overall ^c	28.7	1.00	Ref	40.1	1.80	1.59, 2.03
<i>Birth year</i>						
1979 or later	50.2	2.52	1.58, 4.02	48.4	1.33	0.75, 2.37
1973–1978	41.2	1.98	1.35, 2.90	44.3	1.32	0.80, 2.19
1967–1972	36.0	1.72	1.29, 2.29	45.6	1.59	1.02, 2.49
1960–1966	30.6	1.31	1.09, 1.58	41.8	1.40	1.02, 1.92
1959 or earlier	19.3	1.00	Ref	28.6	1.00	Ref
<i>Education</i>						
Less than high school diploma	31.4	1.78	1.23, 2.59	43.6	2.19	1.24, 3.85
High school graduate	36.0	1.90	1.50, 2.41	48.5	2.29	1.56, 3.36
Some college	30.4	1.56	1.24, 1.97	41.8	1.64	1.13, 2.37
Bachelor's degree	22.6	1.18	0.91, 1.53	31.3	1.25	0.84, 1.86
Postgraduate degree	17.3	1.00	Ref	25.1	1.00	Ref
<i>Race/ethnicity</i>						
Non Hispanic white	31.4	1.00	Ref	41.1	1.00	Ref
Non Hispanic black	27.2	0.75	0.61, 0.91	45.6	1.02	0.89, 1.31
Other	26.1	0.81	0.68, 0.96	35.8	0.89	0.68, 1.16
<i>Marital status</i>						
Not married	36.2	1.01	0.86, 1.19	43.8	1.14	0.94, 1.40
Married	28.2	1.00	Ref	38.3	1.00	Ref
<i>Smoking status in 2004</i>						
Persistent never smoker	28.4	1.00	Ref	39.7	1.00	Ref
Persistent former smoker	30.9	1.09	0.95, 1.26	40.9	1.03	0.81, 1.30
Recent quitter	37.7	1.23	0.97, 1.57	48.3	1.20	0.80, 1.78
Current smoker	31.1	0.87	0.73, 1.03	43.2	0.98	0.74, 1.28
<i>Body mass index (kg m⁻²)</i>						
<18.5	35.3	1.33	0.48, 3.74	53.7	1.86	0.97, 3.56
18.5–24.9	26.7	1.00	Ref	36.1	1.00	Ref
25.0–29.9	29.7	1.35	1.16, 1.56	47.5	1.62	1.32, 1.98
≥30	36.2	1.82	1.50, 2.21	41.1	1.24	0.86, 1.79
<i>Posttraumatic stress disorder symptoms</i>						
No	29.5	1.00	Ref	40.2	1.00	Ref
Yes	41.4	1.20	0.89, 1.61	51.9	1.34	0.89, 2.02
<i>Depression symptoms</i>						
No	29.6	1.00	Ref	40.5	1.00	Ref
Yes	44.0	1.39	0.97, 2.01	49.5	1.19	0.76, 1.86
<i>Deployment experience between the 2001 and 2004 surveys</i>						
Not deployed	28.1	1.00	Ref	39.3	1.00	Ref
Deployed without combat exposures	32.4	1.14	0.94, 1.37	48.2	1.26	0.90, 1.77
Deployed with combat exposures	38.9	1.25	1.05, 1.49	52.0	1.50	1.05, 2.14
<i>Service component</i>						
Active duty	31.1	1.00	Ref	38.1	1.00	Ref
Reserve/National Guard	24.2	0.52	0.43, 0.63	41.8	0.71	0.55, 0.91
<i>Branch of service</i>						
Army	32.1	1.00	Ref	41.9	1.00	Ref
Navy/Coast Guard	25.5	0.62	0.52, 0.72	38.3	0.79	0.61, 1.01
Marine Corps	42.7	1.26	0.98, 1.61	46.8	1.13	0.66, 1.93
Air Force	28.1	0.90	0.74, 1.09	40.7	1.15	0.86, 1.54
<i>Years of military service</i>						
<10	41.4	1.00	Ref	44.6	1.00	Ref
10–13	38.3	1.09	0.82, 1.44	45.7	1.06	0.75, 1.50
14–20	29.9	0.93	0.67, 1.29	40.2	0.95	0.63, 1.41
21–25	29.1	0.96	0.68, 1.35	37.1	0.88	0.56, 1.39
≥26	18.2	0.77	0.52, 1.13	30.0	0.97	0.54, 1.76
<i>Discharge group</i>						
Discharged between 2001 and 2004	29.1	1.00	Ref	38.8	1.00	Ref
Discharged between 2004 and 2007	31.0	1.01	0.89, 1.15	43.5	1.11	0.91, 1.35

Abbreviations: CI, confidence interval; OR, odds ratio. ^aClinically important weight gain defined as ≥10% body weight gain. ^bAdjusted for all variables in the table. ^cThis row is read across (odds ratio of clinically important weight gain in women vs men) whereas all other odds ratios are read down, within a column. Bold font indicates $P < 0.05$.

Several limitations should be mentioned. First, weight was self-reported. Most validation studies have found that both women and men tend to overreport their height, and women underreport their weight, suggesting that weights, weight changes and calculated BMI may be underreported.¹⁹ It is uncertain whether bias in estimates due to self-reported weight and height might differ between service-discharge groups, potentially resulting in biased estimates. Because all service branches require regular body composition testing, continuing service members might have been more likely to have known their weight and reported it accurately. Additionally, a greater proportion of those who were discharged from the military during follow-up were overweight or obese at baseline; individuals who are overweight and obese have been observed to be more likely to underreport their weight than normal weight individuals. However, as the groups differed on other characteristics that may be associated with validity of self-report (for example, sex, age, education, mental and physical health conditions), in the absence of objective data (that is, measured weight and height), it is not possible to ascertain the direction or the magnitude of the potential bias.

Second, because individuals were only queried approximately every 3 years, it was not possible to determine whether the weight gain among those who were discharged occurred before or after discharge, or whether it was over a few weeks or months or over a longer time interval. Additionally, positive screens for PTSD or depression were assessed using a self-reported questionnaire and cannot be considered surrogates for a clinical diagnosis of disease. However, mental disorders captured in this manner may reflect a higher burden of disease than would be seen through medical record review, since not all individuals with symptoms present for care. Nonetheless, it is also possible that individuals may underreport symptoms on questionnaires.

Generalizability of study results to individuals with shorter durations of service or who were otherwise different from the population in the current study (including those who first entered the military after 2001) may be limited since 80% of the Cohort had been in the military for at least 10 years. In addition, it was not possible to assess weight change in survey non-responders, who were younger, less educated and more likely to have left the military.^{9,20} If weight changes in non-responders were systematically different than in responders, this could have introduced bias. However, prior investigations have not demonstrated bias due to non-response.²⁰ Additionally, given the characteristics of non-responders and associations between these characteristics and obesity/weight gain, any bias present may be conservative, and thus underestimating the true weight-change differences between individuals who were and were not discharged from the military during follow-up.

In sum, this study provides the first evidence for an increased rate of weight gain around the time of military discharge that may help to explain previously reported high rates of overweight and obesity in veterans⁴ and identified several subgroups that may be at particularly high risk of weight gain following discharge (for example, younger age, less educated, overweight/obese and deployers with combat exposures). All service branches offer weight management programs for those who fail to meet body composition standards (<http://www-nmcphc.med.navy.mil/HealthyLiving/WeightManagement/shipshape/overview.aspx>).^{21,22} Without the requirement to meet the body weight standards or the assistance provided by military weight management programs, individuals transitioning to civilian life may have insufficient knowledge, resources and/or internal motivation to prevent unhealthy weight gain. Determining successful methods to promote weight loss, or at a minimum, prevent or attenuate weight gain in new veterans is essential to preventing illnesses caused or exacerbated by obesity. Such weight management support, if successful, could not only improve the health and

reduce the risk of chronic illness in veterans, but also potentially reduce health-care expenses for this population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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14. ABSTRACT <p>Background: Although obesity is less prevalent among active-duty military personnel compared with similar persons not serving in the military, no such difference has been seen between veterans and nonveterans.</p> <p>Purpose: To compare the trajectory of weight change between personnel on active duty and those who separate from the military, and to evaluate how these changes differ depending on demographic, service-related, and psychological characteristics.</p> <p>Methods: We used data from the baseline (2001) and follow-up (2004 and 2007) Millennium Cohort Study ($n=38,686$). We estimated average annual and 6-year weight changes as well as multivariable adjusted odds ratios of clinically important weight gain ($\geq 10\%$). Analyses were conducted in 2010.</p> <p>Results: Individuals gained a substantial amount of weight (7–8 pounds) around the time of their separation from service. While the rate of annual weight gain among those leaving service returned to the rate of continuing service members, the additional weight gained after separation was not lost. Consequently, 6-year weight gain in separators was 4 to 5 pounds greater than in those who did not separate (12–13 pounds vs. 8 pounds). Subgroups that were at increased risk of weight gain following separation included active duty (vs. Reserve/National Guard), those who were depressed, and deployers with combat exposures (vs. nondeployers).</p> <p>Conclusions: This study provides the first evidence for an increased rate of weight gain around the time of military separation that may explain previously reported higher rates of overweight and obesity in veterans. High-risk subgroups identified may require enhanced resources to prevent unhealthy weight gain.</p>						
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